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SUBMISSION OF CERTIFIED TRANSLATION OF PRIORITY DOCUMENT

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SERIAL NO.:	10/564,078	EXAMINER: Nancy Bitar
FILED:	January 9, 2006	CONFIRMATION NO.: 7105
TITLE:	METHOD FOR THE PRODUCTION OF A CORRECTED X-RAY IMAGE DATA SET	

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S I R:

Applicant herewith submits a Certified Translation of German Application 103 32 344.9, filed in the German Patent and Trademark Office on July 16, 2003, on which Applicant bases his claim for convention priority under 35 U.S.C. §119.

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TRANSLATOR'S DECLARATION AND CERTIFICATE

APPLICANT: **Schulz**

SERIAL NO.: 10/564,078

FILED: January 9, 2006

TITLE: "METHOD FOR THE PRODUCTION OF A CORRECTED X-RAY IMAGE DATA SET"

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S I R:

I, Charles Bullock, declare and state that I am knowledgeable in German and English, and I hereby certify that the attached translation of the attached German Priority Application 103 32 344.9, filed in the German Patent and Trademark Office on 16 July 2003, is truthful and accurate to the best of my knowledge.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATE: 2 May 2008

FEDERAL REPUBLIC OF GERMANY

Priority Document concerning the Submission of a Patent Application

File number:	103 32 344.9
Application date:	16 July 2003
Applicant/patent holder:	Siemens Aktiengesellschaft, Munich/DE
Title:	Method for the production of a corrected x-ray image data set
IPC:	H 05 G, G 06 T, A 61 B

The attached pieces are a correct and precise reproduction of the original documents of this application.

Munich, the 7th of July 2004
German Patent and Trademark Office
The President
by order
[signature]
Schäfer

Specification

METHOD FOR THE PRODUCTION OF A CORRECTED X-RAY IMAGE DATA SET

The invention concerns a method for correction of the pixels of an x-ray image data set.

X-ray apparatuses comprise a memory or image plate, for example, as an x-ray detector. It can thereby respectively be a substrate on which an x-ray memory luminophore layer is deposited. Such an image plate is typically arranged in a cassette. The x-ray radiation attenuated upon penetration through the examination subject strikes the memory film as an x-ray intensity distribution and is absorbed there. Electrons in luminophore crystals are thereby transitioned to an excited, meta-stable state. The electrons located in an excited, meta-stable state are excited again with photo-simulation [sic] and consequently revert to their ground state. Light proportional to the x-ray intensity distribution is thereby emitted and detected with a readout device that is suitable and known to the average man skilled in the art from, for example, Schulz, Forschungsbericht Röntgenstrahlung 2001 (173), pages 1137 – 1146. A computer downstream from the readout device calculates an x-ray image data set from the read data.

The sensitivity of the memory film can be inhomogeneous, such that given exposure of the image plate with a homogeneous x-ray intensity distribution the corresponding x-ray image exhibits different grey values. In order to compensate the inhomogeneous sensitivity of the memory film, the individual pixels of the x-ray image data set can therefore be corrected (and in particular normalized) with a respective correction values associated with the individual pixels. The individual correction values can, for example, be experimentally determined for an individual image plate before its delivery and be stored once on a data storage of the readout device.

Moreover, given specific materials for the memory film the sensitivity can change with the accumulated x-ray radiation to which the memory film. Such materials are, for example, doped alkali halogenides, for example KBr, RbI, RbBr, CSBr doped with IN, Ga, TL and/or Eu. Since the x-ray radiation is attenuated by the examination subject, the applied x-ray doses of the individual sub-regions of the memory film differ. For example, the boundary regions of the memory film are thus normally exposed to a higher x-ray dose than regions near the middle of the memory film. In general, the accumulated x-ray doses of the individual sub-regions of the memory film thus differ. The sensitivities of the sub-regions of the memory film consequently also change differently with time, i.e. with the number of x-ray image data sets produced.

It is therefore the object of the invention to specify a method in which the changing sensitivities of the sub-regions of the memory film due to the accumulated x-ray doses of the memory film are accounted for in the correction.

The object is achieved via a method for correcting the pixels of an x-ray image data set, possessing the following method steps:

- acquisition of an x-ray exposure of an examination subject with an x-ray apparatus that comprises a memory film as a radiation detector, which memory film possesses a memory luminophore layer, wherein the sensitivity of the memory luminophore layer changes with the accumulated x-ray dose that the memory luminophore layer is exposed to,

- readout of the memory film with a readout device after the x-ray exposure,

- generation, from the data determined via the readout process, of an x-ray image data set associated with the x-ray exposure and

- correction of each image point of the x-ray image data set with a correction value associated with the corresponding pixel, wherein each individual correction value is adapted based on the accumulated x-ray dose that the part of the memory film that is associated with the corresponding pixel of the x-ray image data set was exposed to before the x-ray exposure.

Since the sensitivity of the memory film changes differently with the respectively accumulated x-ray dose, the correction value is thus inventively adapted for each pixel of the x-ray image data set due to the accumulated x-ray dose to which sub-regions of the memory film were exposed. The change of the sensitivity of a specific memory luminophore can thereby be experimentally determined from measurements as a function of the accumulated x-ray dose. For a type of memory film or, respectively, memory luminophore, the function $EB_{i,j}^{m} = f\left(D_{i,j}^{m}\right)$ (thus the correction value for the m-th x-ray exposure) can be determined as a function of the accumulated x-ray dose $D_{i,j}^{m}$ in order to then correspondingly adapt the individual correction values. More or less complex functions (such as, for example, overlapping e-functions) result depending on the memory film material.

According to a variant of the invention, the m-th x-ray image data set (thus the current x-ray image data set to be generated) is corrected according to the following relation:

$$B_{i,j}^{m} = a * RB_{i,j}^{m} / EB_{i,j}^{m}.$$

a is thereby a first scaling factor, $RB_{i,j}^{m}$ is the signal of the pixel i, j of the m-th x-ray image data set, $EB_{i,j}^{m}$ is the correction value for the pixel i, j of the m-th x-ray image data set and $B_{i,j}^{m}$ is the signal of the pixel i, j of the m-th corrected x-ray image data set. This type of correction is a normalization of the x-ray image data set.

In some cases (such as, for example, given CsBr:Eu as a memory film material) the change of the sensitivity given typically applied x-ray doses is linear with the accumulated x-ray dose. According to a preferred embodiment of the method according to the invention, the accumulated x-ray dose $D_{i,j}^{m}$ for the sub-region of the memory film that is associated with the pixel i, j is therefore determined according to the following relation for the m-th x-ray image data set:

$$D_{i,j}^{m} = \sum_{n=1}^{m-1} b * B_{i,j}^{n},$$

wherein b is a second scaling factor.

According to a preferred variant of the inventive method, the correction value $EB_{i,j}^{m}$ for the pixel i, j of the m-th x-ray image data set can thus be determined according to the following relation:

$$EB_{i,j}^{m} = EB_{i,j}^{0} - s * \left(\sum_{n=1}^{m-1} b * B_{i,j}^{n} \right),$$

wherein s is a constant and $EB_{i,j}^{0}$ is the correction value that is associated with the memory film without applied x-ray dose.

The correction values can also be smoothed by means of low-pass filtering for noise suppression. Since the applied x-ray dose per exposure can also be relatively small, it can be sufficient that the correction values are not updated given each exposure. Under the circumstances it can thus be sufficient to implement an updating after 10, 100 or even after 1000 exposures.

An exemplary embodiment is exemplarily shown in detail in accompanying schematic Figures. Shown are:

Fig. 1 an x-ray apparatus with a memory plate,

Fig. 2 a readout device for the memory plate shown in Fig. 1 and

Fig. 3 a graphical representation of the change of the sensitivity of the memory plate shown in Fig. 1 as a function of the accumulated x-ray dose.

In a schematic view, Fig. 1 shows an x-ray apparatus with a memory plate 1 possessing a memory film. An x-ray beam 3 (whose edge rays are shown with dashes in Fig. 1) emanating from the x-ray source 2 of the x-ray apparatus is attenuated upon passage through an examination subject (a patient 4 in the case of the present exemplary embodiment) and strikes the memory plate 1 as an x-ray intensity distribution. The x-ray intensity distribution is absorbed by the memory film which, in the case of the present exemplary embodiment, comprises an x-ray luminophore layer made up of CsBr:Eu.

After the x-ray exposure the memory plate 1 is evaluated with a readout device 20 schematically shown in Fig. 2 and, for example, known from Schulz, Forschungsbericht Röntgenstrahlung 2001 (173), pages 1137 – 1146. An incident surface of the memory plate 1 is homogeneously exposed with light by means of the readout device 20. The light consequently emitted by the memory plate 1 is detected and transduced into a matrix-like x-ray image data set by means of a data processing device 21 of the readout device 20. In order to compensate the sensitivities of different sub-regions of the memory film of the memory plate 1 due to different accumulated x-ray doses, in the case of the present exemplary embodiment the individual pixels of the x-ray image data set are corrected according to the following:

$$B_{i,j}^{m} = a * RB_{i,j}^{m} / EB_{i,j}^{m},$$

wherein a is thereby a scaling factor, $RB_{i,j}^{m}$ is the signal of the pixel i, j of the x-ray image data set, $EB_{i,j}^{m}$ is a correction value for the pixel i, j of the x-ray image data set and $B_{i,j}^{m}$ is the signal of the pixel i, j of the corrected x-ray image data set. The index m thereby means that it concerns the m-th x-ray image data set or, respectively, that (m-1) x-ray exposures were already produced with the memory plate 1 before the current x-ray exposure. In the case of the present exemplary embodiment, the x-ray image associated with the corrected x-ray image data set comprising the individual pixels $B_{i,j}^{m}$ can be considered with a monitor 22 connected with the data processing device 21.

In the case of the present exemplary embodiment, the x-ray memory luminophore layer of the memory plate 1 changes its sensitivity linearly with the accumulated x-ray dose $D_{i,j}^{m}$ and in fact as is graphically shown in Fig. 3. In the case of the present exemplary embodiment, the individual correction values $EB_{i,j}^{m}$ associated with the corresponding pixels $RB_{i,j}^{m}$ of the x-ray image data set are therefore calculated according to the following relation:

$$EB_{i,j}^{m} = EB_{i,j}^{0} - s * \left(\sum_{n=1}^{m-1} b * B_{i,j}^{n} \right).$$

b and s are thereby further constants, wherein s is the slope of the correction value as a function of the accumulated x-ray dose. $EB_{i,j}^{0}$ is the correction value of the x-ray memory luminophore layer without applied x-ray dose or, respectively, at a specific point in time at which the correction value was experimentally determined, for example.

Patent claims

1. Method for correcting the pixels of an x-ray image data set, possessing the following method steps:

- acquisition of an x-ray exposure of an examination subject (4) with an x-ray apparatus that comprises a memory film (1) as an x-ray detector, which memory film (1) possesses a memory luminophore layer, wherein the sensitivity of the memory luminophore layer changes with the accumulated x-ray dose that the memory luminophore layer is exposed to,

- readout of the memory film (1) with a readout device (2) after the x-ray exposure,

- generation, from the data determined via the readout process, of an x-ray image data set associated with the x-ray exposure and

- correction of each pixel of the x-ray image data set with a correction value associated with the corresponding pixel, wherein each individual correction value is adapted based on the accumulated x-ray dose that the part of the memory film that is associated with the corresponding pixel of the x-ray image data set was exposed to before the x-ray exposure.

2. Method according to claim 1, in which the individual pixels $RB^m_{i,j}$ of the m-th x-ray image data set are corrected according to the following:

$$B^m_{i,j} = a * RB^m_{i,j} / EB^m_{i,j},$$

wherein

a is a first scaling factor,

$RB^m_{i,j}$ is the signal of the pixel i, j of the m-th x-ray image data set,

$EB^m_{i,j}$ is the correction value for the pixel i, j of the m-th x-ray image data set and

$B^m_{i,j}$ is the signal of the pixel i, j of the m-th corrected x-ray image data set.

3. Method according to claim 2, in which the accumulated x-ray dose $D^m_{i,j}$ for the sub-region of the memory film (1) that is associated with the pixel i, j of the x-ray image data set is determined according to the following relation for the m-th x-ray image data set:

$$D^m_{i,j} = \sum_{n=1}^{m-1} b * B^n_{i,j},$$

wherein b is a second scaling factor.

4. Method according to claim 3, in which the correction value $EB^m_{i,j}$ for the pixel i, j of the m-th x-ray image data set is determined according to the following relation:

$$EB^m_{i,j} = EB^0_{i,j} - s * \left(\sum_{n=1}^{m-1} b * B^n_{i,j} \right),$$

wherein s is a constant and $EB^0_{i,j}$ is the correction value that is associated with the memory film without applied x-ray dose.

Abstract

Method for the production of a corrected x-ray image data set

The invention concerns a method for correcting the pixels of an x-ray image data set. An x-ray exposure of an examination subject (4) is initially generated with an x-ray apparatus that comprises a memory film (1) as an x-ray detector, which memory film (1) possesses a memory luminophore layer, wherein the sensitivity of the memory luminophore layer changes with the accumulated x-ray dose that the memory luminophore layer is exposed to. After the x-ray exposure the memory film (1) is evaluated with a readout device (2) and an x-ray image data set associated with the x-ray exposure is generated from the data determined via the readout process. Each pixel of the x-ray image data set is subsequently corrected with a correction value associated with the corresponding pixel, wherein each individual correction value is adapted based on the accumulated x-ray dose that the part of the memory film (1) that is associated with the corresponding pixel of the x-ray image data set was exposed to before the x-ray exposure.

Fig. 1